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Zoology

Report on the Study and Appraisal of Mussel Resources in Selected Areas of the Upper Mississippi River, 1920-25 ..... *N. M. Grier, Ph.D.* 113

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Report on the Study and Appraisal of Mussel Resources in Selected Areas of the Upper Mississippi River, 1920-25.*

N. M. GRIER,

DARTMOUTH COLLEGE HANOVER, N. H.

(*Conclusion*)

AREA II.

Boundaries, Red Wing, Minn., to Bay City, Wis., Status, closed to fishery in 1920, open in 1925. Length in linear miles, 5.8, physical conditions, 1920, 7 ft. high water, current about 3 miles per hour. Bottom mostly sand and mud, snags more abundant toward Wisconsin shore. Water weed in lower stretches of area. Water at least five feet below normal stage, in 1925.

Localities Reported Upon, (Ref. Maps).

II-1. Starting point of drags 300 ft. upstream off Wisconsin shore from Government Day Mark 958-c on edge of main channel about 40 ft. from shore, July 10, 1920. Aug. 20, 1925, starting point about 300 ft. above where Day Mark was in 1925, opposite small inlet, 25, 40, and 50 ft. from shore. Bottom showing evidence of decaying organic matter.

II-2. Starting point of drags 35 ft. from shore about ¼ mile downstream from Government Day Mark 958-d opposite bathing houses and summer camp on Minnesota shore, July 10, 1920. Aug. 22, 1925 drags 40, 60, 75 ft. from shore below Day Mark 958-c, former locality of 958-d. Bottom showing evidence of decaying organic matter, with refuse flowing on the surface.

II-4. Starting point of drags 100 ft. downstream from Government Day Mark 958-b, 45 ft. from Minnesota shore, July 10, 1920. Aug. 22, 1925, drags 12, 25 and 40 ft. from shore. Bottom muddy, free from snags.

Notes on Area II.

The data obtained for this area is of interest as indicating how certain species of shells have become localized in parts of it, and have remained so over the five-year period. As this area became open to fishery during the last year, an increase in the absolute abundance of shells in 1925 over 1920 should be demonstrated if the protective laws were the sole factor at work. This increase however was noted in but one locality and for commercial species only. As regards the relative abundance of shells in these areas it was observed for commercial species that there have been small increases in the pimple backs, blue points, river muckets, and larger ones in the Lake Pepin muckets and pocketbooks. The greatest decrease in commercial shells is shown in the hickory nuts with smaller decreases in the three ridges and long johns. Of the non-commercial species observed the majority, (including the *Anodontas* and *Leptodea fragilis*), show decreases in both the absolute and relative abundance of shells. *Strophitus edentulus*, whose button making potentialities have been considered from a genetical standpoint, shows a slight increase in abundance.

In view of what has been presented concerning these shells in the discussion concerning Area I, the losses in the larger species of *Anondonta* are remarkable. To the writer, the data presented as a whole indicates an unhealthy condition for mussel life in the area, possibly due to the stream pollution of which some amount has already been given. Masses of refuse covered with blue green algae were common on the surface of the water one mile below Red Wing. Pocketbooks were present in this area to a greater extent than the previous one, and with hickory nuts and Lake Pepin muckets are the dominating group of shells. The relative increase in the number of Lake Pepin muckets should be a source of gratification to those concerned with propagation of this species in Lake Pepin, as

the proportion obtained from a locality fairly near the lake is greater in 1925 than it was in 1920. It is encouraging also to note that the number of juveniles collected in this area in 1925 is greater than it was in 1920, especially of the last named species. *Quadrula verrucosa, Lasmigona complanata,* and *Amygdalonaias donaciformis* were not encountered in this area during 1925.

The water weeds and *Sphaeridae* previously mentioned continued abundant. Dense growths of *Sagittaria latifolia* bordered the river in the lower portions of the area, and the masses of dead *Lemna,* (duck weed) on the shores resembled burnt cork particles. Algae associated with the refuse were sent to Dr. W. R. Taylor, Botanical Laboratory, University of Pennsylvania and determined by him to be the following: *Tribonema* sp., *Oscillatoria tenuis, Oscillatoria prolifica, Oscillatoria chalybdea, Oscillatoria splendida, Clathrocystis aeruginosa, Arthrospira Jenneri.* Associated with these were the following species of diatoms determined by Mr. Paul Conger of the U. S. National Museum to be *Asterionella formosa* Hassal, *Cocconeis Pediculus* Ehr., *Cocconeis Placentula* Ehr., *Cymatopleura solea* (Breb.) Ralfs., *Diatoma vulgare* Bory, *Encyonema turgidum* Grun., *Epithemia Zebra* (Ehr.) Kütz, *Frustulia rhomboides* (Ehr.) DT., *Hantzschia Amphioxys* Grun., *Melosira granulata* (Ehr.) Ralfs., *Melosira roeseanc* Rabh., *Melosira subflexilis* Kütz, *Navicula appendiculata* (Ag.) Kütz., *Navioula Bacillum* Ehr., *Navicula cryptocephala* Kütz., *Navicula cuspidata* Kütz, *Navicula pygmaea* Kütz., *Navicula Reinhardtii* Grun., *Nitzschia acicularis* (Kütz.) W. Sm. *Nitzschia littoralis* Grun., *Nitzschia Sigma* var. *rigida* (Kütz.) Grun., *Pleurosigma acuminatum* (Kütz.) Grun., *Pleurosigma scalproides* Rabh., *Pleurosigma Spencerii* var. *acutiuscula* Grun., *Stephanodiscus Astraea* (Ehr.) Grun., *Surirella apiculata* W. Sm., *Surirella ovata* Kütz., *Synedra delicatissima* W. Sm.

Attention may be recalled to the very productive bed of shells existing in the channel of the Mississippi river in the vicinity of our locality II-7, near which the river enters the lake.

AREA III.

Boundaries, Bay City, Wis., to Maiden Rock, Wis., and Frontenac, Minn. Status, subject to fishery in 1920, closed to fishery in 1925. Length in linear miles, 5.7. Physical conditions, 1920, 7 ft. high water. Current about 2 miles per hour, bottom; gravel, mud with some sand. Comparatively free from snags. Water weeds common in upper stretches of area. Water at least 5 ft. below normal stage in 1925.

Localities Reported Upon. (Ref. Maps.)

III-1. Lake Pepin, starting point of drags 1500 ft. towards point with Government Light 957, from Wacouta Point, Minn., 100 ft. from shore, starting at a clump of low willows July 14, 1920. Aug. 24, 1925, drags 75, 100, 115 ft. from shore. Bottom snaggy.

III-4. About two miles below Bay City on Wisconsin shore starting a clump of willows and poplars at lower end of promontory with an altitude of 680. Drags 75 ft. off shore, July 15, 1920. Aug. 24, 1925, drags 15, 25 and 40 ft. from shore. Bottom snaggy.

III-8. Drags from Point No Point to Frontenac Point in a straight line between them, starting 300 ft. from shore of first and finishing 75 ft. from shore of second, July 16, 1920. Aug. 25, 1925, drags starting 250 ft. diagonally from shore of Point No Point toward Frontenac, 60, 80, and 40 ft. from shore.

Notes on Area III.

Obovaria ellipsis, Lampsilis higginsii, Obliquaria reflexa, Lasmigona complanata, Elliptio niger were not collected in this area by us in 1925, while we obtained here for the first time *Amygdalonais truncata, Lampsilis fallaciosa*, a single specimen of *Quadrula verrucosa*, and several specimens of *Quadrula metanevra*, and *Proptera laevissima*.

As a rule there has been no absolute decrease in the number of shells except in the locality nearest the head of the lake, in both commercial and non-commercial shells. Relatively, there has been an appreciable increase in the following commercial species; washboards, Lake Pepin muckets, long johns, and spikes; appreciable decreases are shown in the pig-

toes and pink heel splitters. It is again possible that the increase in Lake Pepin muckets may be attributed to the propagation work in this species carried on by the Bureau of Fisheries in the lake. Practically no change is recorded for the pocketbooks. It would seem that they should have increased in Lake Pepin if swept in from the upper river, but as clamming is most intensive in Lake Pepin, they may have taken in such numbers as to neutralize any normal increase. A relative decrease is noted for all species of non-commercial shells. This may be explained by clammers destroying them rather than being bothered by catching them again. In some instances this is known to be a fact.

Juveniles were less abundant than in 1920. In years gone by, a large portion of this area in the vicinity of Bay City was the site of a great deal of seining, but such is less frequently carried on now. The gradual filling in of the lake at its head or other factors contributing to the destruction of the feeding grounds of the fish, also contribute to conditions making for a scarcity of mussel life in that vicinity. Lake Pepin muckets, pig toes, blue points and spikes are the dominating shells of this area according to these observations, with all except the second species on the increase.

While our Loc. III-1 had been clammed 2-3 years ago we found it barren, with few or no dead shells on the shore. The water weeds already mentioned were present in abundance and many specimens of the snail *Campeloma subsolidum* Anthony, were associated with them. Additionally we found the water weed *Naias flexilis* at Maiden Rock. At one of our localities in this area we noticed for the first time during the trip, Aug. 4, 1925, the phenomenon of "breaking of the meres," although this may have occurred earlier in the sloughs further north. In 1920, these bluish green masses which were thick in the water of coves of the lake at that time, were identified by Dr. G. T. Moore, Director of the Missouri Botanical Garden as consisting of a mixture of *Clathrocystis serrigensa*, *Coelospharium kuetzingianum*, and *Anabeana flos-aquae*. The fresh water sponge, *Spongilla fragilis* Leidy was common on submerged sticks and stones as well as the fresh water

bryozoan, *Pectinatella magnifica.* Damsel flies which were rather common at this time were determined by Mr. Hugo Kahl of the Carnegie Museum, Pittsburgh, Pa., to be a male specimen of *Enallagma carunculatum* Morse. Diatoms from the mud below low water mark, Lake Pepin, at Lake City, Minn., were determined by Mr. Conger to be *Cocconeis Pediculus* Ehr., *Cocconeis Placentula* Ehr., *Cymbella Mexicanum* (Ehr.) Mann (this species is vastly dominant in the sample), *Encyonema turgidum* Grun., *Gomphonema eriense* Grun., *Rhoicosphaenia curvata* var. *subacuta* A. S. (common in this sample), *Stephanodiscus Astraea* (Ehr.) Grun., *Synedra Goulardi* (Breb.) Grun., *Synedra ulna* Ehr.

AREA VI.

Boundaries, Pepin and King's Coulee to Read's Landing, Minn., Status closed to fisheries in 1920, open to in 1925. Length in linear miles, 4. Physical conditions in 1920, 4 ft. high water, current about 2 miles per hour. Bottom mud, sand with a great deal of water weed, on the Wisconsin side. Cobbles, gravel and riff-raff on the Minnesota shore. 1925, about 5 ft. of low water.

Localities Reported Upon. (Ref. Maps.)

VI-3. Starting point of drags, 700 ft. north of points marked 682.09 and 673.42 on map at foot of Lake Pepin, 500 ft. off shore, July 27, 1920. Aug. 27, 1925, drags 150, 100, 175 ft. from shore.

VI-5. Starting Point, 1000 ft. southwest of C. M. and St. P. R. R. trestle at culvert opposite Knud Johnston's coulee, (1760 elevation), 150 ft. from shore. July 28, 1920. Aug. 26, 1925, drags 75, 100, 125 ft. from shore.

VI. One mile upstream from bridge at Read's Landing, 300 ft. s. w. of C. M. & St. P. R. R. at base of stone quarry, 700 ft. from Minnesota shore, July 28, 1920. Aug. 28, 1925, drags 600, 700, 800 ft. from shore.

Notes on Area VI.

Fusconaja ebena, Obovaria olivaria, (except one deal shell), *Anodonta corpulenta, Rotundaria granifera* and *Aridens confragosus* were not collected by us in this area in 1925. On the

other hand, the following species absent in 1920 appeared in 1925: *Amblema costata, Megalonaias heros, Actionaias carinata, Lasmigona costata, Elliptio niger,* and *Truncilla triquetra.*

This area, recently opened to fishery, showed a marked decline in the absolute abundance of shells during the past five years. It is true that it had been intensively clammed during the summer, and that here we saw more clammers at work than on any other area of the Mississippi. A decline was found also in the absolute abundance of commercial shells for perhaps the reason cited. Appreciable increases in the relative abundance of commercial shells were seen only in the long johns. The Lake Pepin muckets appear to be hardly holding their own, while losses are shown by the pocketbooks, pigtoes, spikes and some minor species. These include *Anodonta grandis, Anodonta corpulenta,* and *Leptodea fragilis.* One-half of the non-commercial species show a relative loss.

Juvenile shells also show a marked decrease except in that section nearest the foot of the lake. It could hardly be said that the above data for this area indicated the presence of unfavorable conditions. There was no indication of stream polution and the clamming operations going on showed that clamming was unprofitable. The situation seems best explained by the fact that our rig did not obtain the shells at a time when clammers were obtaining them with pitchforks, and that what had been large beds before were now broken up into smaller units by the clamming operations which commenced with a rush when the area was reopened. The dominating species found in the area are in order the Lake Pepin muckets, (possibly as an effect of propagation experiments), pocket books, blue points, spikes, and long johns.

Dead shells were more numerous on the bottom of this area than any other with the exception of Straight Slough. Large numbers of them were young niggerheads. Many of them were still marketable, although there seemed to be no effort to take them. This condition was especially true of that portion of the lake south of Pepin where water weeds were abundant. Most of the shells we obtained at the foot

of Lake Pepin were young looking and their regular lines of growth indicated their origin in the lake. We found more spikes and elephant ears in this area than in any other.

The water weeds already mentioned were quite abundant at the foot of Lake Pepin. A brownish alga-growth from Lake Pepin, near Lake City, was determined by Dr. W. R. Taylor to consist of a growth of *Rhizoclonium* sp. covered with *Cymbella, Gomphonema, Cocconeis* and other diatoms. Other green algae forming green mats along the shore in the same vicinity were pronounced by him to consist of *Rhizoclonium heiroglyphicum, Clathrocystis* sp. and *Lyngbya majuscula.* Professor E. N. Transeau, Head of the Department of Botany, Ohio University, determined green algae from the shore of Lake Pepin near the ice house at Lake City to be *Oedogonium* sp. *Stigeoclonium* sp., and *Chaetophora incressata.* Another algae forming large yellowish green mats at the foot of Lake Pepin and particularly noticeable on account of the low stage of the water was pronounced by him to be mostly *Cladophora crispata* (Roth) Kuetzing. Mr. Conger determined diatoms associated with these algal mats to be *Cocconeis Pediculus* Ehr., (abundant here,), *Cocconeis Placentula* Ehr., (abundant here), *Cymbella granulata* (Ehr.) Ralfs, *Navicula Reinhardtii* Grun., *Nitzschia fonticola* Grun, *Rhoicosphaenia curvata* var. *subacuta* A. S. (abundant here), *Synedra Goulardi* (Breb.) Grun., *Synedra ulna* Ehr.

AREA VII.

Boundaries, Read's Landing, Minn., to Minneiska, Minn., Status, open to fishery 1920, closed in 1925. Length in linear miles, 20.9. Physical conditions, 1920, 5 ft. high water, current 4-6 miles per hour. Bottom sandy with many imbedded snags especially in the upper portions of areas.

Localities Reported Upon. (Ref. Maps).

A. Results with crowfoot bars.

VII-4. 320 ft. upstream from Government Light 946 along water front at Wabasha, 49 ft. from shore, July 31, 1920. Aug. 31, 1925, drags 40, 30, 60, 80 ft. from shore. Bottom snaggy.

VII-6. Teepeeota Point, 350 ft. west of willows at point,

150 ft. from shore line, July 31, 1920. Aug. 31, 1925, drags 35, 50, 75 and 20 ft. from shore. Bottom covered with water weeds.

VII-14. Off Alma, Wis., starting 450 ft. north of R. E. Jones Mill, 40 ft. from shore, Aug. 3, 1920. Sept. 1, 1925, drags 20, 40, 50 ft. from shore.

B. Results from picking by hand from sandbars.

Loc. VII-22. Sand bars northwest of Belvedere Island, Aug. 5, 1920. Sept. 2, 1925.

Loc. VII-23. Sandbars on island to left on entering West Newton Chute. Aug. 5, 1920. Sept. 2, 1925.

Loc. VII.-28. Sand bars off Belvedere Island, Miss. R., Aug. 6, 1920. Sept. 3, 1920.

Notes on Area VII.

Pleurobema catillus was not encountered in this area in 1925, while *Lampsilis fallaciosa* was collected here for our first time.

When we consider the results obtained by the use of the crowfoot bars, these indicate that there has been a marked decline in the absolute abundance of shells in this area in the past five years, both in commercial and non-commercial species. As however, conditions in the river below Lake Pepin did not permit us to form an accurate idea of the mussel resources by the use of the crowfoot bars, we substituted instead picking by hand from the sand bars. Since each drag occupied the space of 90 minutes in collecting and listing the shells, it was arranged that the three members of the party collect by hand with buckets and list the shells during a similar period. Where beds had been destroyed by the sand being pumped to the opposite side of the river, as in the case of those at Fountain City, Wisconsin, we collected on the sand bars thus formed and studied these results in place of those ordinarily obtained by using crowfoot bars.

When we considered the results obtained in 1925 by picking from the sand bars, we observed that there had been an increase in the relative abundance of shells on certain sand bars over what was found there in 1920, both in commercial and non-commercial species. When we studied, however, the

results obtained by the use of crowfoot bars we found that there had been an enormous increase in pocketbooks, and smaller ones in blue points while the Lake Pepin muckets showed on the whole a positive increase, possibly due again to the propagation work. The rest of the commoner commercial species generally showed losses.

Pigtoes, which showed a loss by the crowfoot bar results, exhibited a large increase when collected from the sand bars while three ridges, pocketbooks, and blue points on the sand bars are on the increase as well as white heel splitters. There is also an increase in floaters, while the number of Lake Pepin muckets, as collected from sand bars by hand show a loss.

While we found few enough juveniles in 1925, yet the total was greater than those found in 1920. So far as the clam beds in this area are concerned, pocketbooks, blue points, Lake Pepin muckets and deer toes are the dominating shells, while on the sand bars pocketbooks are still the most frequent shell followed by pigtoes, and white heel splitters, and in non-commercial species, by the floaters.

Elodea and *Ceratophyllum* were abundant in this area. In the pools behind the sand bars were abundant growths of algae determined by Professor O. E. Jennings, Head of the Department of Botany, University of Pittsburgh, to consist of the blue green algae *Anaboena Flos-aquae*, Breb., *Phormidium tenue* (Menegh.) Dument, *Oscillatoria* sp., *Clathrocystis aeruginosa* (Kuetz.) Henf. The green algae *Spirogyra* sp., *Hydrodictyon reticulatum*, *Scenedesmus quadricauda* (Turp.) Breb., *Scenedesmus incrassulatus* Breb. and the diatoms *Cymbella cuspidata* Kuetz., *Navicula* sp., *Synedra Vaucheriae* Kuetz., *Meridion constrictum*, *Cyclostella* sp., *Melosira* sp. Aquatic insect larvae and nymphs collected from a submerged log near Alma, Wis., consisted of nymphs of the dragon fly *Epicordulia princeps*, a leptid fly larva, perhaps *Atherix*, and many specimens of *Hydropsyche* sp. There were also nymphs of the stone fly. *Pteronarcys dorsata* and of the dragon fly, *Neurocordulia obsoleta* and larvae of parnid beetles. These were determined by Dr. J. G. Needham.

AREA VIII.

Boundaries, Minneiska, Minn., to Fountain City, Wis. Status, closed to fishery in 1920, open in 1925. Length in linear miles, 10.8. Physical conditions, 1920, 2 ft. high water, current about two miles per hour. Bottom, sand, mud, cobbles, riff-raff and infested with snags. 1925, about 4 ft. of low water.

Localities Reported Upon. (Ref. Maps.)

A. Results with crowfoot bars.

Loc. VIII-1. Starting at Government Light 902, 35 ft. off shore south of island 49, Aug. 11, 1920. Sept. 8, 1925, three-tenths mile upstream from 1925 location of this light, drags 15, 40, 50 and 70 ft. from shore with no results. Substituted collection by hand from sand bars on opposite side of river from this locality.

Loc. VIII-10. One-half mile around the bend from Government Light 896, 35 ft. off shore, starting point adjacent to coulee south of Chimney Rock, Aug. 14, 1920. Sept. 7, 1925. One-tenth of a mile downstream from 1925 location of the light, 3 drags with one bar 20, 40 and 60 ft. from shore with no results, and collection by hand from the sand bar opposite equally ineffective.

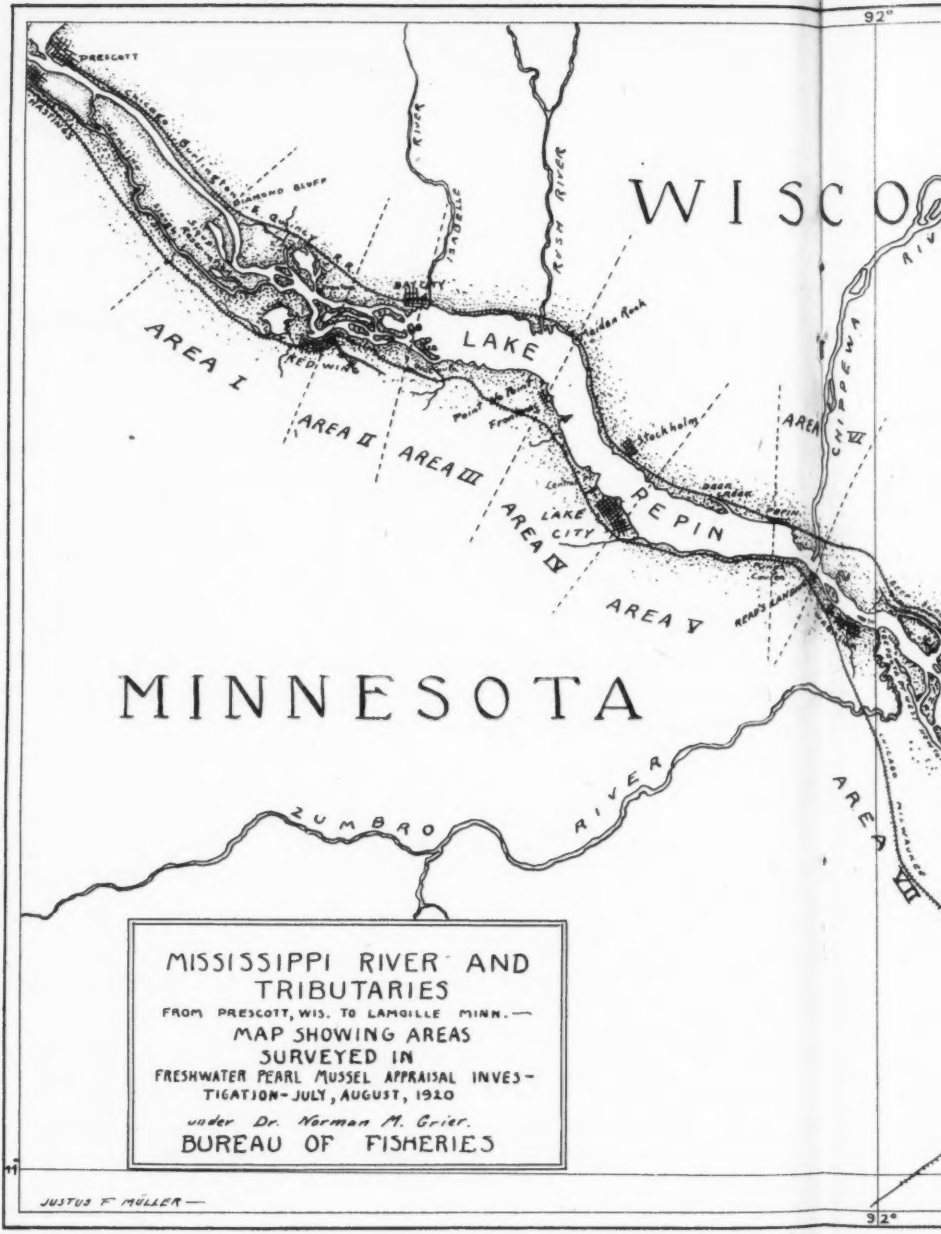
Loc. VIII-19. Straight Slough, 100 ft. south of the north end of the first large slough leading from it (at upper end), to the C. M. & St. P. R. R. tracks from 655 elevation on the opposite shore at distance of 20 ft. from tracks, Aug. 16, 1920. Sept. 8, 1925—the stage of water too low to permit entrance.

B. Results from picking by hand from sandbars.

Loc. VIII-4. Sandbar lower end of Belvedere Slough opposite 665 elevation on either bank and starting at 660 elevation on the island. Aug. 13, 1920.

Loc. VIII-5. Island and sand bar in Belvedere Slough in vicinity of map point B. M. 669.22; 665.29, Aug. 13, 1920.

Loc. VIII-14. Sand bars at end of Island 55. Aug. 16, 1920.



MISSISSIPPI RIVER AND TRIBUTARIES

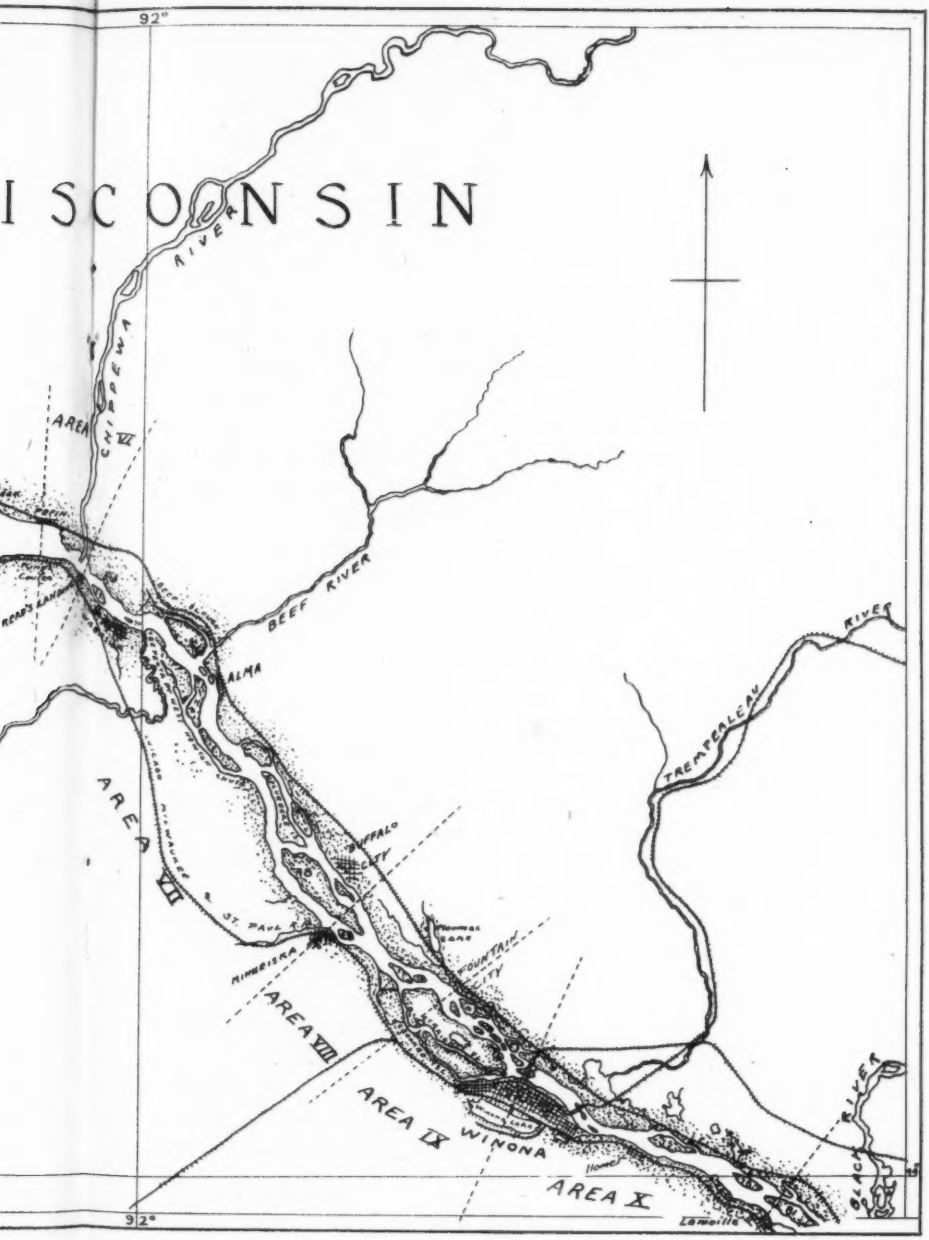
FROM PRESCOTT, WIS. TO LAMOILLE MINN.—

MAP SHOWING AREAS SURVEYED IN FRESHWATER PEARL MUSSEL APPRAISAL INVESTIGATION - JULY, AUGUST, 1920

under Dr. Norman M. Grier.

BUREAU OF FISHERIES

JUSTUS F. MÜLLER—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I SC O N S I N
CHIPPEWA RIVER
AREA VII
BEEF RIVER
ALMA
TREMPEALEAU RIVER
AREA VIII
BUFFALO CITY
MINNESOTA
MINNESOTA & ST PAUL
MINNESOTA
FOUNTAIN CITY
AREA VIII
AREA IX
WINONA
AREA X
BLACK RIVER
La Crosse
92°

Notes on Area VIII.

Dams constructed by the government destroyed Loc. VIII-1 and Loc. VIII-10 studied by the writer in 1920. In the first locality very few dead shells were found on the shore or sand bars where the locality formerly existed. We next investigated the sand bar on the opposite side of the river which had been formed since 1920 and found abundant dead bullheads, spikes, pocketbooks, niggerheads, three ridges, buckhorns, pigtoes, long johns, both kinds of muckets and heel splitters, and a few dead juveniles. There were a few living three ridges, buckhorns, pigtoes, long johns, both kinds of muckets and heel splitters, and a few dead juveniles. There were a few living three ridges and pigtoes. In the second locality mentioned, nothing was found on the sand bars opposite this point in the river indicating that this, the old Chimney Rock bed of the clammers, is destroyed.

Our results from the sandbars indicate an absence from this area in 1925 of the following species *Fusconaia ebena*, *Eurynia subrostrata*, *Pleurobema catillus*, and the appearance in this area in our observations of *Amygdalonaias donaciformis*, *Arcidens confragosus*, *Lampsilis anodontoides*, *Quadrula verrucosa*.

We obtained no results whatsoever from crowfoot bars in any of the localities of this area at which we had used them in 1920. Comparing the results of collecting by hand from the sandbars in 1920 and 1925, it is found that the shells have increased in absolute abundance and that the commercial species represented by the pimple backs, hickory nuts, blue points, three ridges, and white heel splitters have relatively increased also. A decided loss is recorded for the pigtoes, pocketbooks, and Lake Pepin muckets. In the case of the latter species the region is too far away for propagation work to be felt. Among the non-commercial shells one of the forms of paper shells shows an increase (*Proptera laevissima*) and another, (*Leptoolea fragilis*) a decrease. Juveniles were decidedly more abundant in 1920. The shells most frequently found in the area were pocketbooks, pigtoes and three ridges. It is believed that the further decline in the

absolute abundance of shells in this area is due most largely to the various government activities in the improvement of the river. A leech collected from the clams taken in the vicinity of Island 55 was identified by Professor J. Percy Moore as *Placobdella parasitica*. A rather common spider inhabiting the sandbars in the vicinity of Fountain City, Wis., was determined by Professor Alexander Petrunkevitch of Yale University to be probably *Arctosa littoralis* (Hentz).

AREA IX.

Boundaries, Fountain City, Wis., to Winona, Minn., at high bridge. Status, open to fishery in 1920, closed in 1925. Length in linear miles, 8.6. Physical condition 2 ft. high water, current 4 miles per hour. Bottom gravel and mud, with less amount of riff-raff than in preceding areas. 1925, three feet of low water.

Localities Reported Upon.

A. Results with crowfoot bars.

Loc. IX-2. South end of Island 62, across the mouth of a slough, starting 20 ft. from nearest shore. Aug. 18, 1920. Sept. 9, 1925, drags 20, 40, 75 and 100 feet from Wisconsin shore. After no results, substituted three collecting ½ hr. from sand bars of vicinity.

Loc. IX-22. Straight Slough about 3 miles from mouth, across the mouth of the first slough above island with 655 elevation, 25 ft. from north shore, Aug. 21, 1920. Sept. 10, 1925, 3 collecting by hand from the sand bars of the vicinity.

Loc. IX-31. 800 ft. northwest of the C. M. St. P. R. R. bridge at Winona, 35 ft. from sheer boom, Aug. 23, 1920. Sept. 11, 1925, drags at 25, 40, 60 and 125 ft. from shore.

B. Results picking by hand from sand bars.

Loc. IX-6. Sand bars opposite lower entrance to Pap Slough Aug. 18, 1920. Sept. 9, 1925.

Loc. IX-8. Sandbars in vicinity of north end of Island 65 and 66 on northwest shore. Aug. 18, 1925, Sept. 7, 1925.

Loc. IX-30. Sand bar just north of high bridge at Winona on Wisconsin shore, Aug. 23, 1920. Sept. 11, 1925.

Notes on Area IX.

We did not encounter *Fusconaia ebena* or *Plagiola lineolata* in this area during 1925. We collected for the first time in the area *Quadrula quadrula*, *Lampsilis higginsii* and *Lampsilis anodontoides*. With the exception of one sandbar locality on which there was an enormous increase, shells have declined in absolute abundance in this area during the past five years, both as regards commercial and non-commercial species. As regards relative abundance pimple backs show an increase, as well as blue points. Pocketboooks, strangely enough show an increase in the clam beds proper but a slight decrease is noted in the numbers of these obtained from the sand bars, while white heel splitters increase in both types of localities. Among the non-commercial species, the squaw foot is on the increase in the clam beds as well as one of the paper shells, *Leptodea fragilis*. The latter is also abundant on the sand bars.

Most of the living shells seen in Loc. IX-22 were younger ones, the more prominent species being indicated by the table. On the other hand there were many very large dead bullheads, niggerheads and river muckets. The conditions prevailing in Straight Slough as they concern the mussel resources have been discussed in the remarks on the status of the mussel fisheries in the region surveyed. At our locality IX-30 a sand bar immediately north of the high bridge at Winona, Minn., we observed as in 1920, that many pocketbooks had been cut open for pearls, presumably by the foreign element of the population of Winona.

Propagation carried on in Lake Pepin shows little effect on the distribution of the Lake Pepin mucket. More juveniles of all species were collected from the clam beds and sand bars in 1920 than in 1925. The percentages establish that the principal shells in the area are blue points, pocketbooks, white heel splitters, pimple backs, long johns, pigtoes and hickory nuts. An exquisite red dragon fly observed in Straight Slough was pronounced by Mr. Hugo Kahl to be a male specimen of *Sympetrum rubicundulum*, Say, while masses of algae in the pools behind the sand bars were determined by Professor I. F.

Lewis, Head of the Department of Botany, University of Virginia to be *Hydrodictyon reticulatum* (L.) Lagerheim.

From Betsey slough, near Fountain City, we obtained a specimen of the nymph of the dragonfly, *Gomphus externus* as identified by Dr. Needham.

AREA X.

Boundaries, Winona, Minn., high bridge to La Moille, Minn., Status, closed to fishery in 1920, open in 1925. Length in linear miles 7.2. Physical conditions 2 ft. high water, current 4 miles per hour. Bottom sand and gravel, many snags. In 1925, 3 ft. of low water.

Localities Reported Upon.

A. Results with crowfoot bars.

Loc. X-4. Drags 15-25 ft. from sheer boom, 450 ft. north of Burlington bridge at Winona, off Minnesota shore, Aug. 24, 1920. Sept. 11, 1925, drags 15, 20, 40 and 60 ft. from sheer boom.

Loc. X-6. Above Homer, starting opposite 700 ft. elevation and dragging down to point with 655 elevation, 25 ft. off Minnesota shore, Aug. 25, 1920. Sept. 14, 1925, drags 18, 20, 25 and 40 ft from shore.

Loc. X-9. Starting at point adjacent to Homer to 680 elevation, 25 ft. from shore, Aug. 25, 1920. Sept. 14, 1925. Drags 18, 20, 25, 40 ft. from shore.

B. Picking by hand from sand bars.

Loc. X-7. Sand bar directly opposite Homer, Minn. Aug. 25, 1920. Sept. 12, 1925.

Loc. X-12. Sand bars in vicinity of Island 76. Aug. 26, 1920. Sept. 14, 1925.

Loc. X-14. Sand bars off island 78. Aug. 26, 1920. Sept. 12, 1925.

Notes on Area X.

Our results from this area may be affected by the fact that our locality X-4 was extensively clammed this summer, while Loc. X-6 was worked off and on by 6-8 clammers dur-

ing this period. In addition to the shells we obtained from Loc. X-6 we saw nearly a bucketful of three ridges, buckhorns and river muckets from this locality. Loc. X-9 represents the best instance of the effect of the protective laws which came to our notice although for the reason indicated it is not substantiated by our own data. At the time the area had been closed five years ago, few or no shells existed there, but during the past summer 4 or 5 men worked this locality, one clammer getting five tons out of here at the first of the season, with clams on every hook. Afterwards, they picked by hand with considerable success. This bed is stated to be a very narrow one.

In 1925 we failed to collect the following species in Area X, *Fusconaia ebena, Eurynia subrostrata, Proptera alata.* So far as the clam beds themselves are concerned, the shells show a decrease in absolute abundance and this occurs on the sandbars also. The fact that this area shows a large number of increases in relative abundance than any other area below Lake Pepin may somewhat compensate for this condition. The increases in commercial shells in the clam beds in order of magnitude are hickory nuts, monkey faces, pocketbooks, pimple backs, and long johns. On the sandbars the increases are found to be in the blue points, Lake Pepin muckets and white heel splitters among commercial shells, and the squawfoots and *Anondontas* in the non-commercial group.

Juveniles as a rule were most abundant in 1920. The Lake Pepin mucket was somewhat more abundant in this area than in the preceeding one. A brick red sediment on the banks of the sloughs and ponds in this vicinity was determined by Dr. G. T. Moore to consist of the flagellate genus *Uglena.* Associated with these forms were the green algae *Hydrodictyon reticulatum* (L). Lagerh., *Coelastrum microsporum* Naegeli, *Melosira varians Agardh.* and the diatoms *Navicula* (2 sp.) *Gyrosigma Tenuatum* Kuetz, *Fragillaria* sp. and abundant *Peridinium* sp. These latter were kindly determined by Dr. O. E. Jennings.

VII.—CONCLUSIONS

From the data presented under the heading of each area, the following tabulation is made dealing with the absolute abundance of shells in the areas appraised. For Areas VII, VIII, IX and X the results having their basis on collections from sand bars are expressed in parentheses.

Area and Status as to Fishery	No. Shells—Commercial Species Per Linear Mile 1920	1925	No. Shells—Commercial Species Per Linear Mile 1920	1925	Average All Shells Per Linear Mile 1920	1925
I. Closed	197.1	48.3	66.	15.7	263.1	64.
II. Open	84.1	62.6	47.9	16.	131.5	78.6
III. Closed	39.	26.3	6.61	4.4	44.61	30.7
*IV. Open	92.		10.3		102.3	
*V. Closed	166.8		7.		173.8	
VI. Open	243.25	52.	15.5	2.	258.75	54.
VII. Closed	14.5 (16.13)	3.6 (9.1)	1. (6.55)	*(2.3)	15.5 (22.68)	3.6 (11.4)
VIII. Open	10. (43.)	.3 (46.8)	1.2 (2.8)	*(3.5)	11.2 (45.8)	.3 (50.3)
IX. Closed	28.24 (54.)	7.4 (14.6)	4.76 (7.6)	2.1 (2.2)	33. (61.6)	9.5 (16.8)
X. Open	45.3 (62.91)	18.3 (10.4)	4. (8.3)	1.7 (6.8)	49.3 (71.20)	20. (17.2)

* For data concerning these areas see report of J. B. Southall.

From the preceding tables, it is concluded that under the conditions in which the surveys of 1920 and 1925 were made:

I.—That the fresh water mussels considered as a whole have declined in absolute abundance during the past five years in the regions between Diamond Island, and La Moille, Minn., despite the favoring action of protective laws. This decline is observed for commercial species in areas I, II, III, VI, VII, IX, X and for non-commercial species in areas I, II, III, VI, VII, IX, X. Judged by the results of collecting on sand bars there are slight increases in absolute abundance of both commercial and non-commercial shells in Area VIII, but the yields from crowfoot bars show a distinct loss.

II.—That certain commercial species have come to make up a larger proportion of the Naiad fauna, in the areas considered as a whole during the past five years. Such are *Pleurobema catillus,* (niggerhead), *Quadrula quadrula* (maple leaf), *Obliquaria reflexa* (three horned warty back), *Fusconaia undata,* (pigtoe), *Amblema peruviana,* (blue-point), *Amblema costata,* (three ridge), *Megalonaias heros,* (washboard), *Quadrula verrucosa,* (buckhorn), *Lampsilis anodontoides,* (yellow sand shell), *Lampsilis fallaciosa,* (slough sand shell), *Eurynia recta,* (long john), *Elliptio niger,* (elephant ear), totalling twelve species.

III.—That non-commercial species which have similarly increased are *Anodonta imbecillis,* (paper shell), *Strophitus edentulus,* (squaw foot), *Proptera laevissima,* (paper shell), totalling three species.

IV.—That other commercial species constitute a less proportion of the Naiad fauna in the areas considered in 1925 than they did in 1920. Such are *Fusconaia ebena,* (niggerhead), *Obovaria olivaria,* (hickory nut), *Quadrula pustulosa,* (pimple back), *Quadrula metanevra,* (maple leaf), *Actinonaias carinata,* (river mucket), *Lampsilis higginsii,* (higgins' eye), *Lampsilis siliquoidea,* (Lake Pepin mucket), *Plagiola lineolata,* (butterfly), *Amygdalonaias truncata,* (deer toe), *Lampsilis ventricosa,* (pocketbook), *Lasmigona complanata,* white heel splitter), *Lasmigona costata,* (fluted shell), *Proptera alata,* (pink heel splitter), *Arcidens confragosus,* (rock pock-

etbook), *Elliptio dilatatus,* (spike), *Amygdalonaias donaciformis,* (sugar spoon), totalling sixteen species. In this group are found the most important button making shells.

V.—That non-commercial shells which have similarly decreased are *Anodonta grandis,* (slop bucket), *Anodonta corpulenta,* (paper shell), *Leptodea fragilis,* (paper shell).

VI.—That within the limits of the observations made by the writer's party, the reasons assignable for such a decrease are those discussed most fully in the section of the report dealing with the staus of the mussel fisheries in the areas surveyed, viz., smothering of mussel beds by sand deflected from the dams, destructive fishing methods, stream pollution, lack of a correlating factor in conservation activities.

VIII.—REMARKS AND RECOMMENDATIONS

On the basis of the preceding information it is recommended:

I.—To the United States Engineers, the Game Commissions of the States of Wisconsin and Minnesota through the agency of the U. S. Bureau of Fisheries, that further plans for the improvement of the channel of the Upper Mississippi beyond the developments reached in 1925 be the subject of mutual discussion with the idea of giving the Game Commissions and the Bureau of Fisheries the opportunity to conserve if possible the mussel life which may be imperilled by such improvements.

II.—To the Game Commissions of the State of Minnesota and Wisconsin through the U. S. Bureau of Fisheries, the following is cited as apparently falling in their province for action, viz.,

(a). That effort be made to prevent the increasing degree of stream pollution in the areas studied.*

(b). That restriction of clamming operations be limited to one individual per license.

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* With regard to this situation, the writer is in receipt of the following letter, Nov. 2, 1925, from the State Board of Health of Wisconsin: "You will probably be interested to know that at a recent meeting of the interim committee of the State of Wisconsin and Min-

(c). That clear interpretation of the protective laws be made as regards the practice of taking clams by hand in closed areas.

(d). That provision be made to guard clams against exceptional stages of low water where this occurs in an area subject to fishery.

(e). That all sloughs below Lake Pepin to La Moille be closed to mussel fishery until that stretch of the river has returned to normal conditions through the agency of engineering improvements, when it may be restocked with shells from these sloughs.

(f). That the recommendations made in the preceding be kept vigorously in force by the game wardens of the states concerned checking up the list of the clammers operating in their vicinity.

III.—Of the United States Bureau of Fisheries it is urged:

(a). That rescue work for mussels on sand and mud bars, in pools back of dams and wherever large numbers of clams are exposed by low water by low water conditions be made a larger part of the program of the fish rescue crews.

(b). That where sites of old clam beds still appear favorable to mussel life, such be restocked with commercial species when in the judgment of the government engineers the river has returned to normal conditions.

(c). That the coöperation of shell buyers be obtained toward standardizing the prices paid for mussel shells in order that there be no incentive leading to violation of the protective laws, and toward rejection of immature and illegally sized shells when presented by inexperienced clammers.

IV.—That the recommendations presented in I and II to the U. S. Engineers and the Game Commissions of Wisconsin and Minnesota have the official support of the U. S. Bureau of Fisheries where such appears to be practicable.

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nesota, it was planned that a study should be made of the condition of the Mississippi River below the twin cities of St. Paul and Minneapolis with the ultimate object of removing the pollution coming from these two cities."

BOOK REVIEWS

In this section are reviews of new, or particularly important and interesting books in the fields of natural science. Books dealing with botany or kindred subjects should be sent to the Editor, the University of Notre Dame. *All other books for review* should be sent to Carroll Lane Fenton, at the Walker Museum, the University of Chicago, Ill. Publishers are requested to furnish prices with books.

PRINCIPLES OF GENETICS By Sinnott and Dunn. McGraw-Hill Book Co., Price, $3.50.

Genetics belongs to that category of science that is still so young that uniform standards for the treatment of its various subdivisions have not yet been formulated. The particular interest of the author, whether in plants or in animals, is usually apparent from the general content and method of treatment that the various subjects receive throughout the book. The joint authorship of a botanist and a zoologist, therefore, leads us to expect a more balanced presentation of the subject as a whole. This expectation is realized in Principles of Genetics. The presentation is uniformly clear, concise and accurate. The four hundred and seventeen pages of text present the subject in a manner that leaves little to be desired. A feature of the book that is especially desirable is the questions for thought and discussion and the reference assignments at the end of each chapter. There is a good bibliography as well as a complete table of contents and an index. We wonder, just why Mendel was made a Franciscan abbot, as we read on page 8. It ought to be a matter of common knowledge that there are no Franciscan abbots, and that the monastery at Brunn, where Mendel lived and worked, is even to this day in the care of the Augustinians. —F. W.